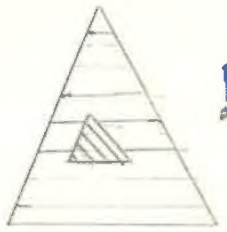
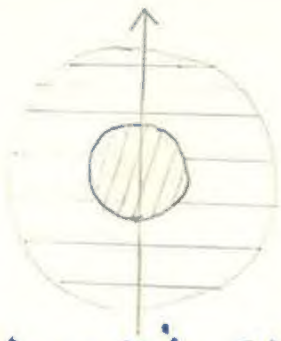
DEVELOPMENT OF A FIELD THEORETIC PROGRAMME



paradigm shift →



classical N-particle theory

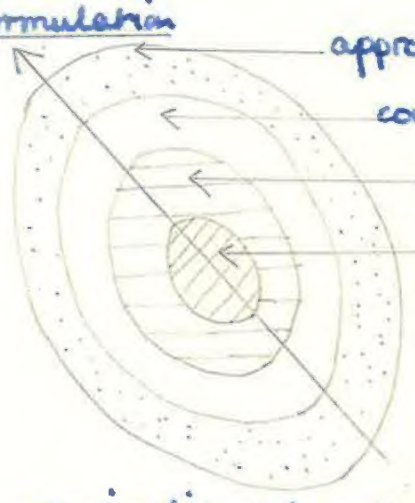
N-particle Schrödinger Eqn.

directional shift →

stretching of theory →

2nd quantization formulation

Testable consequences and novel predictions →

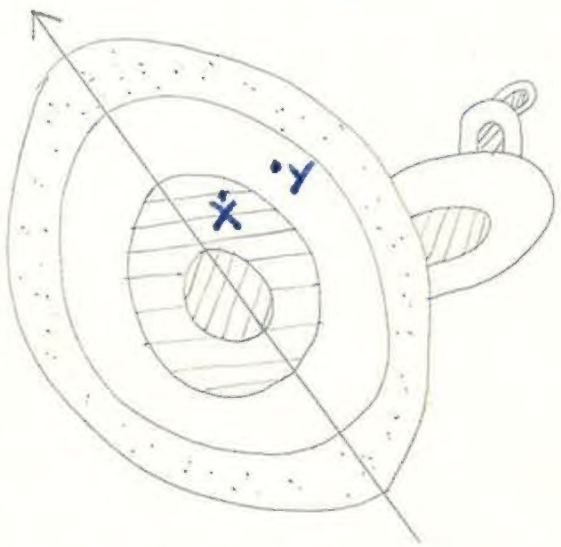


variable no of particles

approximation scheme for field theory

problem shift →

according to the positive heuristic of the programme



either by { alteration at x → new theory
alteration at y → new 'model' of old theory

Surplus structure

Involve additional mathematical 'objects'

(1) e.g. additional points on a real line, or complex plane

(2) Also involve mathematical operators

e.g. ∂t, ∂t^2, $\dot{q}$, $\dot{q}^2$ etc.

are part of surplus structure if $q(t)$ is basic ontology. (new vector space LT^{-1} introduced via the derivatives.

Reformulation involves either new mathematical objects e.g. H–L or [illegible] or new equations involving old objects e.g. Lagrange, Hamilton v. Newton. — then usually involves new structure in second of above senses.

Sketching involves giving new surplus structure (in QFT) ontology. or introducing new axioms relating to the new surplus structure (ontologically) in a natural way e.g. Feynman cutoff

Paradigm shift (metaphysical paradigm)
→ change in ontology – not just
additions to ontology.
eg (1) Aristotle to galileo ↳ new ontology of forces
↓
old ontology
of natural tendencies

Ptolemy → Copernicus
motion of earth regarded as impossible
structure in Ptolemy – becomes
real for Copernicus
Einstein revolution
change in ontological status
of contractions framework
Quantum electronics
H-atom to classical mechanics
works better specially
electrons – wave theory of light

1967 – 1968 Weinberg and Salam propose a unified gauge theory of weak and electromagnetic interactions

1971 't Hooft ~~electromagnetic interactions~~ renormalizability of Weinberg-Salam theory

1973 Discovery of neutral currents in weak interactions as predicted by Weinberg – Salam.

1970 SU(4) symmetry (charm) invoked to explain non-existence of strangeness – changing neutral currents in weak interactions

1974 J/ψ particle discovered – explained in terms of charmed quarks

1973–1975 Glashow, Weinberg, Politzer and others develop theory of quark interactions in terms of color gauge symmetry (chromodynamics).

1969 Scaling symmetry in deep inelastic electron-proton collisions suggest parton model of the proton.

1968 Veneziano model of hadrons (leading on to dual resonance models and string models)

1956 — Lee & Yang suggest non-conservation of parity in weak interactions.

1957 — Wu confirms non-conservation of parity in β-decay.

1958 — Mandelstam investigates the analytic properties of the S-matrix and introduces the Mandelstam representation.

1959
(a) Regge introduces the use of complex angular momentum in scattering theory.
(b) Reines and Cowan detect the neutrino.

1961
(a) Chew and Frautschi suggest the bootstrap hypothesis using analyticity in energy and angular momentum.
(b) Gell-Mann and Néeman introduce the new symmetry classification SU(3).
(c) The ρ-meson resonance is discovered.

1963 — ~~The neutretto is discovered.~~ Two sorts of neutrino are distinguished

1964
(a) Gell-Mann and Zweig put forward the quark model.
(b) The Ω^- is discovered as predicted by SU(3).
(c) Non-invariance of weak interactions under time reversal is suggested by experiments on ~~K0~~ K_0 decay.

1965 — Adler and Weisberger ~~produce~~ perform successful calculations of the axial vector coupling constant in β-decay using current algebra.

~~1968-1973 — Recent developments include the duality of resonances and trajectories, the F.E.S.R. bootstrap, the Veneziano model, Feynman's parton model of the proton, and the discovery of neutral currents in weak interactions.~~ gauge theories, Asymptotic freedom, string models, coloured quarks, charmed quarks, ψ particles.

1962 — Gell-Mann proposes a current algebra.

(7)

CHRONOLOGY OF ELEMENTARY PARTICLE PHYSICS.

1897	J.J. Thomson discovers the electron.
1905	Einstein introduces the concept of the photon.
1911	Rutherford proposes the nuclear model of the atom.
1913	Moseley analyses the proton structure of the nucleus from a study of X-ray spectra.
1927-1930	Quantum field theory developed by Dirac, Jordan, Klein, Wigner, Pauli and Heisenberg.
~~1930~~ 1931	Dirac predicts the positron.
1932	(a) Chadwick discovers the neutron.
1932-1933	(b) Anderson and Blackett independently observe the positron.
~~1934~~ 1933	Fermi introduces the neutrino in his theory of β-decay. (following Pauli)
1935	Yukawa predicts the meson.
~~1936~~ 1938	Anderson and Neddermeyer discover the muon.
1940	Pauli proves the spin-statistics theorem.
1943	Heisenberg's S-Matrix.
1947	(a) Powell discovers the pion.
	(b) Lamb and Retherford observe the Lamb shift in hydrogen.
	(c) Bethe explains the Lamb shift by renormalizing the rest mass of the electron.
	(d) Rochester and Butler discover the Λ^{o} hyperon.
1949	(a) Feynman diagrams introduced.
	(b) Dyson proves the renormalizability of spinor electrodynamics to all orders of perturbation theory.
1952	Fermi observes the first baryon resonance, N* (1236).
1953-1955	Gell-Mann and Nishijima introduce a new quantum number, strangeness.
1955	(a) The antiproton is discovered.
	(b) Gell-Mann and Pais predict some remarkable properties of the neutral kaon.
1954	~~(c)~~ Lüders proves the PCT theorem, i.e., invariance of interactions under simultaneous inversion of charge, space and time.

Cont/...

TABLE of the ELEMENTARY PARTICLES

BOSONS	FERMIONS
HADRONS	
MESONS: 150 π (pion); 500 K (kaon); 550 η; + resonances: 750 ρ, 800 ω, 3,100 J/ψ	BARYONS: nucleons {proton, neutron 950}; hyperons {Λ 1100, Σ 1200, Ξ 1300, Π 1650}; + resonances Δ(1232)
o photon o graviton (?) ~~2000~~ ~~15,000~~ 20,000 W-particle (?)	LEPTONS: ν_e (neutrino) o; ν_μ (neutretto) o; e (electron) ½; μ (meion) 100
GLUONS (?)	~~QUARKS (?) 5000~~ QUARKS (?)

(Rest energies in Mev rounded to nearest 50 Mev)